National Aeronautics and Space Administration

Conjunction Assessment NASA Best Practices

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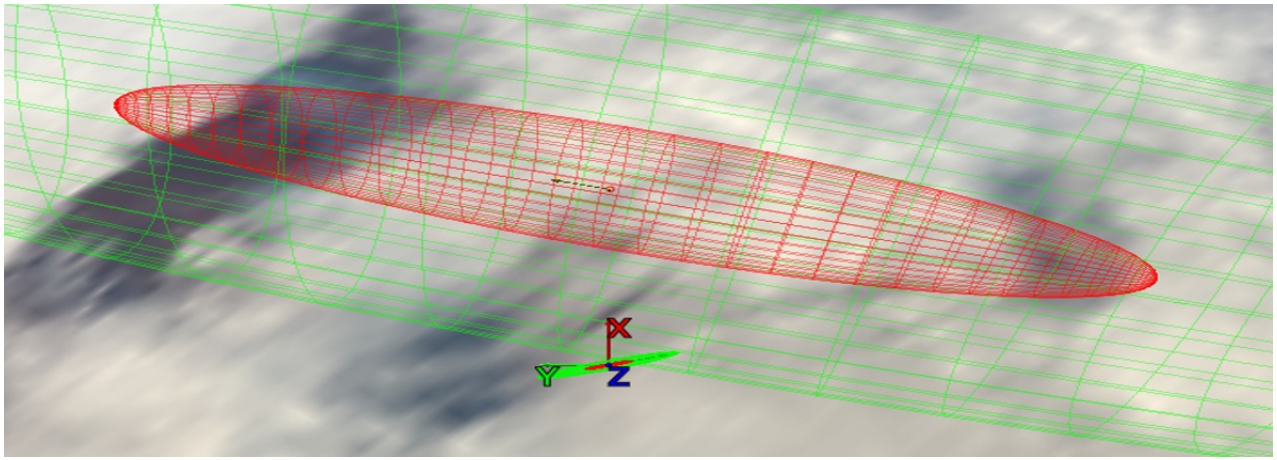
NASA **Conjunction Assessment Risk Analysis**

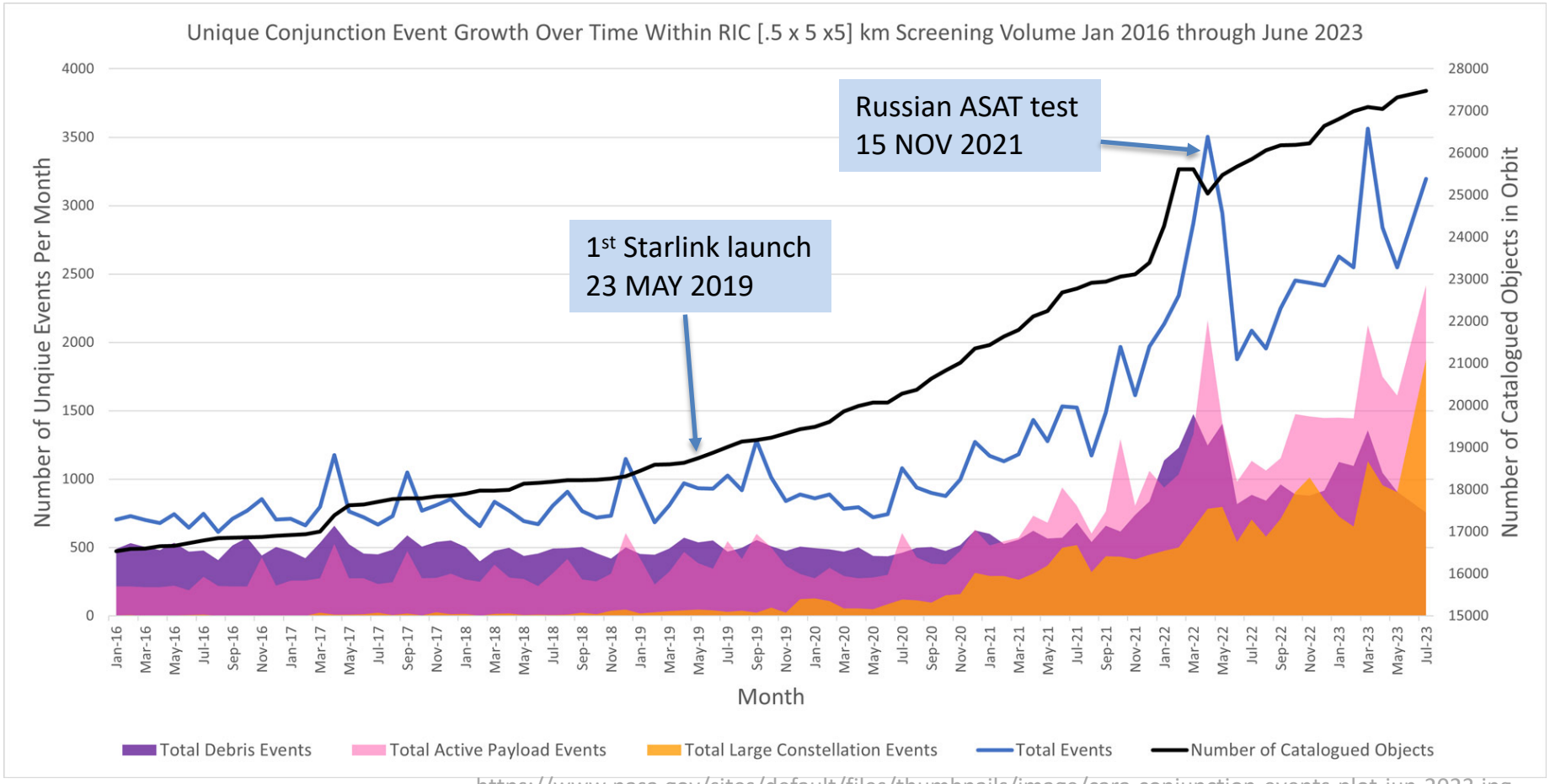
www.nasa.gov

Satellite Conjunction Assessment: Basics

- High-risk satellite conjunction shown below
  - NASA satellite well maintained; small 1-σ (red/inner) / 3-σ (green/outer) error ellipses (with axes at bottom)
  - Debris object "above" it, with very large error ellipses (3-σ extends beyond image)
- Conjunction screening activities find encounters of this nature
- Risk assessment determines that actual likelihood/consequence of collision
- Mitigation planning helps select maneuver for NASA object to avoid collision



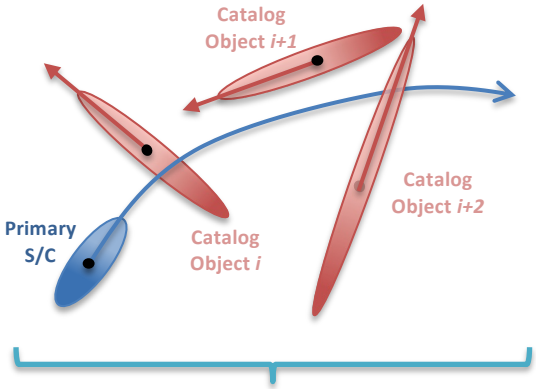
Conjunction Assessment Trends: Situation is Getting Worse!



https://www.nasa.gov/sites/default/files/thumbnails/image/cara-conjunction-events-plot-jun-2023.jpg

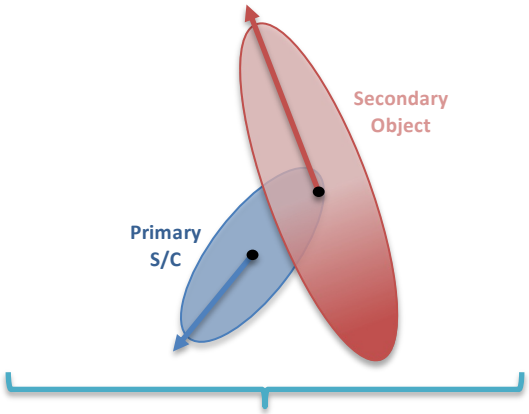
Large constellations will continue to drive the close approach event risk.

Conjunction Assessment: Basic Definitions and Responsibilities



Conjunction Assessment (CA) is the process of identifying close approaches between two orbiting objects; sometimes called **conjunction screening**.

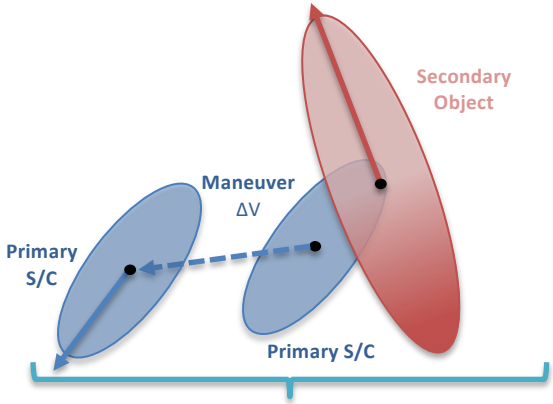
The **18th Space Defense Squadron (18 SDS)** at Vandenberg Space Force Base (VSFB) maintains the high accuracy catalog of space objects. Orbital Safety Analysts (OSAs) at VSFB screen protected assets against the catalog, perform tasking requests, and generate close approach data.



CA Risk Analysis (CARA) is the process of assessing collision risk and assisting satellites in planning maneuvers to mitigate that risk, if warranted.

The NASA **CARA** program performs risk assessment for all NASA operational non-HSF satellites, and some partner missions.

JSC **Flight Operations Directorate (FOD)** performs risk assessment for all NASA Human Spaceflight (HSF) program assets and is the O/O for maneuver decisions and execution.



Collision Avoidance is the process of executing mitigative action, typically in the form of an orbital maneuver, to reduce collision risk.

Each satellite **Owner/Operator (O/O)** – mission management, flight dynamics, and flight operations – is responsible for making maneuver decisions and executing the maneuvers.

Spacecraft Design Considerations

- It is important (and efficient) to make plans for conjunction assessment during spacecraft planning and design
  - CA process needs can be accommodated more easily prior to spacecraft fabrication
  - All processes and tools must be developed and validated well in advance of launch
- Key items to consider during design:
  - Orbit selection
  - Trackability
  - Deployment plan
  - Ephemeris generation process and tools
- Lesson learned example:
  - A NASA spacecraft assumed that two-line elements (TLEs) would be available from DOD for use as acquisition data for tracking radars.
  - After launch, it was discovered that the orbit was too low an inclination for DOD CA sensors to track and maintain it appropriately, so TLEs were not regularly available
  - This situation could have been prevented through pre-launch analysis

Cis-lunar CA

- Catalog of non-cooperatively/passively tracked objects used in CA includes only Earth-orbiting objects
- Activity at Moon, Mars, and Libration points increasing risk of collision; screening of orbits in these regimes now needed
  - NASA MADCAP provides ephem-on-ephem screening for missions
  - Relies on sharing of data
  - Open to non-NASA entities
- DoD developing cis-lunar catalog and screening capability
  - Requirements not yet defined
  - Implementation is still in early stages of development
- NASA continues to work with DoD on beyond GEO SSA capabilities.

Resources

- NASA is committed to refining and sharing appropriate best practices
  - Best practices document available to the public
  - NASA tool sets with test data available to the public
- NASA spacecraft are required to follow best practices
  - Requirements documented in NPR 8079.1
- Accompanying FAQ: https://www.nasa.gov/sites/default/files/atoms/files/faq-nid-and-hbk-collision-avoidance.pdf

NASA CA Handbook

CARA Tool Repository

NASA CA website

Questions?